CLAIMS

What is claimed is:

1. A method for forming a localized halo structure in a semiconductor substrate of a semiconductor device, comprising:

providing a gate structure over the semiconductor substrate;

implanting a dopant material at an angle around the gate structure to form a halo structure in a source/drain region of the semiconductor substrate and underlying a portion of the gate structure;

forming a trench in the source/drain region of the semiconductor substrate, thereby removing at least a portion of the halo structure in the source/drain region; and

forming a semiconductor material layer in the trench using epitaxial deposition.

- 2. The method of claim 1, wherein the semiconductor material layer comprises silicon.
- 3. The method of claim 1, wherein forming the semiconductor material layer comprises:

forming an intrinsic silicon layer in a bottom portion of the trench; and forming a doped silicon layer in a top portion of the trench overlying the intrinsic silicon layer, wherein the trench is substantially filled having a generally undoped region in a bottom portion of the trench and a generally doped region in a top portion of the trench.

4. The method of claim 3, further comprising:

thermally processing the device;

forming a spacer on lateral sidewalls of the gate structure; and performing a source/drain implant into the semiconductor material layer in the trench to form a source and drain region.

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- 5. The method of claim 4, wherein the trench has a depth, and wherein the source and drain region have a depth which is less than the trench depth.
- 6. The method of claim 4, wherein thermally processing the device comprises rapid thermal annealing to slightly grade a junction formed between the undoped silicon material layer and the doped silicon material layer in the trench.
- 7. The method of claim 1, wherein the forming the semiconductor material layer in the trench using the epitaxial deposition comprises filling substantially the entire trench with silicon or SiGe.
- 8. The method of claim 7, further comprising: implanting an HDD dopant into a top portion of the silicon or SiGe in the trench.
- 9. The method of claim 8, further comprising: thermally processing the device; forming a spacer on lateral sidewalls of the gate structure; and performing a source/drain implant into the silicon material layer to form a source and drain region having a depth that is less than a depth of the trench.
- 10. The method of claim 1, wherein forming the trench comprises etching the semiconductor substrate in the source/drain region in a substantially anisotropic manner.
- 11. The method of claim 1, further comprising cleaning the device after the formation of the trench.

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- 12. The method of claim 3, wherein a thickness of the intrinsic silicon layer is greater than a thickness of the doped silicon layer.
- 13. The method of claim 3, wherein the doped silicon material layer comprises one of Si doped with As, SiGe doped with As, Si doped with B and SiGe doped with and B.
- 14. A method for forming a localized halo structure in a semiconductor substrate of a semiconductor device, comprising:

providing a gate structure over the semiconductor substrate;

implanting a dopant material at an angle around the gate structure to form a halo structure in a source/drain region of the semiconductor substrate and underlying a portion of the gate structure;

forming a trench in the source/drain region of the semiconductor substrate, thereby removing at least a portion of the halo structure in the source/drain region; and

forming a silicon material layer in the trench using epitaxial deposition, wherein forming the semiconductor material layer comprises:

forming an undoped silicon material in a bottom portion of the trench; and

forming a doped silicon material in a top portion of the trench overlying the undoped silicon material.

- 15. The method of claim 14, wherein the doped silicon material in the top portion of the trench is doped in-situ during the epitaxial deposition.
- 16. The method of claim 14, wherein the doped silicon material in the top portion of the trench is doped after the epitaxial deposition via ion implantation.

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